

# A Comparison of Edition 4 Beta and Edition 3 Surface-Only Flux Algorithm Results

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Anne C. Wilber<sup>2</sup>, Victor E. Sothcott<sup>2</sup>,  
and P. Sawaengphokhai<sup>2</sup>

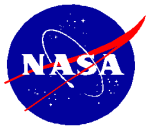
<sup>1</sup>NASA Langley Research Center

<sup>2</sup>Science Systems and Applications, Inc.

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Newport News, Virginia

1-3 May 2012



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## Background (Page 1)

CERES uses several surface-only flux algorithms to compute SW and LW surface fluxes in conjunction with the detailed model used by SARB. These algorithms include:

LPSA/LPLA:  
Langley Parameterized  
SW/LW Algorithm

		Model A	Model B	Model C
SW	Clear	Li et al.	LPSA	--
	All-Sky	--	LPSA	--
LW	Clear	Inamdar and Ramanathan	LPLA	Zhou-Cess
	All-Sky	--	LPLA	Zhou-Cess

### References:

SW A: Li et al. (1993): *J. Climate*, **6**, 1764-1772.

SW B: Darnell et al. (1992): *J Geophys. Res.*, **97**, 15741-15760.

Gupta et al. (2001): *NASA/TP-2001-211272*, 31 pp.

LW A: Inamdar and Ramanathan (1997): *Tellus*, **49B**, 216-230.

LW B: Gupta et al. (1992): *J. Appl. Meteor.*, **31**, 1361-1367.

LW C: Zhou et al. (2007): *J. Geophys. Res.*, **112**, D15102.

SOFA: Kratz et al. (2010): *J. Appl. Meteor. Climatol.*, **49**, 164-180.

SOFA: Gupta et al. (2010): *J. Appl. Meteor. Climatol.*, **49**, 1579-1589.

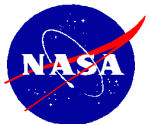


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## Background (Page 2)

- The SOFA LW & SW Models are based on rapid, highly parameterized TOA-to-surface transfer algorithms to derive surface fluxes.
- LW Models A & B as well as SW Model A were incorporated at the start of the CERES project.
- SW Model B was adapted for use in the CERES processing shortly before the launch of TRMM.
- The Edition 2B LW & SW surface flux results underwent extensive validation (See: Kratz et al. 2010), and can be used to provide independent verification of the SARB results.
- The ongoing validation process has already led to improvements to the LW models (Gupta et al., 2010).
- LW Model C will be introduced in Edition 4 processing to maintain two independent LW algorithms after the CERES Window Channel is replaced in future versions of the CERES instrument.



# Recent Improvements to the Surface-Only Flux Algorithms

**SW Model Improvements:** 1) Replacing the ERBE albedo maps with Terra maps greatly improved the SW retrievals, most notably for polar regions. 2) Replacing the original WCP-55 aerosols properties with the MATCH/OPAC data while also replacing the original Rayleigh molecular scattering formulation with the Bodhaine et al. (1999) formulation significantly improved SW surface fluxes for clear conditions. 3) Using a revised empirical coefficient in the cloud transmission formula improved the SW surface fluxes for partly cloudy conditions.

**LW Model Improvements:** 1) Constraining the lapse rate to 10K/100hPa (roughly the dry adiabatic lapse rate) improved the derivation of surface fluxes for conditions involving surface temperatures that greatly exceeded the overlying air temperatures, see Gupta et al. (2010). 2) Limiting inversions to a maximum of 10K for the downward flux retrievals provided the best results for cases involving surface temperatures that were much below the overlying air temperatures (strong inversions).

Parameterized models for fast computation of surface fluxes for both CERES and FLASHFlux

Dataset	CERES 2B	CERES 4A
Clear-Sky TOA albedo Terra	48 month ERBE	70 month Terra
Clear-Sky TOA albedo Aqua	46 month Terra	70 month Terra
Clear-Sky Surf. albedo	46 month Terra	70 month Terra
TOA to Surface albedo transfer	Instantaneous	Monthly average
Spec. Corr. Coef.	CERES 2B	CERES 3A
Cos (sza) dependence of Surface Flux	LPSA	Briegleb-type
Cloud Algorithm Terra	Terra Ed2	Terra/Aqua Ed4
Cloud Algorithm Aqua	Aqua Ed2	Terra/Aqua Ed4
SW aerosol dataset	WCP-55	MATCH/OPAC
Rayleigh Treatment	Original LPSA	Bodhaine et al (1999), JAOT.
Ozone Range Check	0 to 500 DU	0 to 800 DU
Cloud transmission empirical coefficient	0.80	0.75
LW high temperature surface correction	No	Maximum Lapse Rate 10K/100hPa
LW Inversion correction	No	Maximum Inversion limited to 10 K



# Recent Improvements to the Surface-Only Flux Algorithms

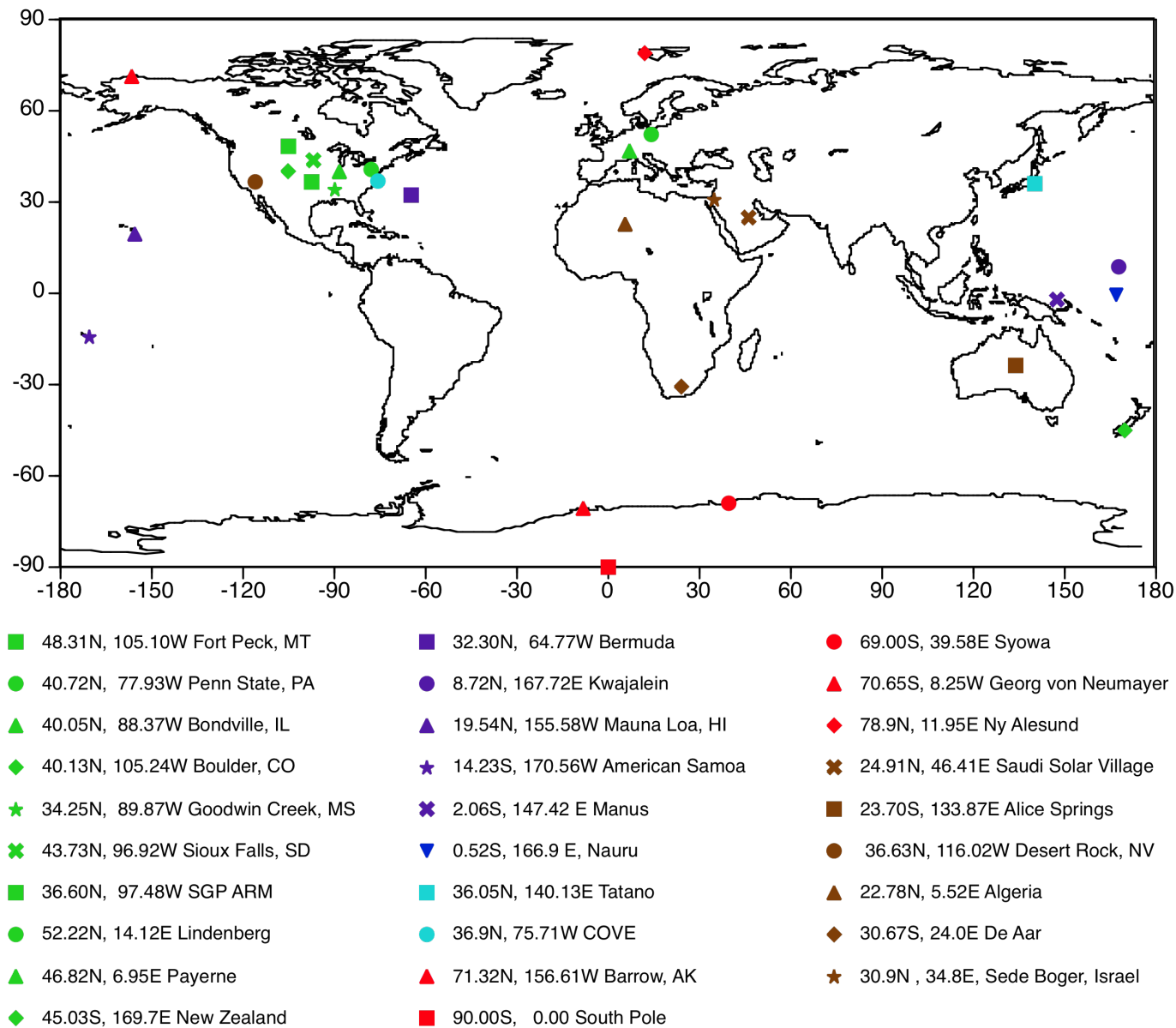
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Parameterized models for fast computation of surface fluxes for both CERES and FLASHFlux

Dataset	CERES 3A	CERES 4A
Clear-Sky TOA albedo Terra	70 month Terra	70 month Terra
Clear-Sky TOA albedo Aqua	70 month Terra	70 month Terra
Clear-Sky Surf. albedo	70 month Terra	70 month Terra
TOA to Surface albedo transfer	Monthly average	Monthly average
Spec. Corr. Coef.	CERES 3A	CERES 3A
Cos (sza) dependence of Surface Flux	Briegleb-type	Briegleb-type
Cloud Algorithm Terra	Terra Ed2	Terra/Aqua Ed4
Cloud Algorithm Aqua	Aqua Ed2	Terra/Aqua Ed4
SW aerosol dataset	WCP-55	MATCH/OPAC
Rayleigh Treatment	Original LPSA	Bodhaine et al (1999), JAOT.
Ozone Range Check	0 to 800 DU	0 to 800 DU
Cloud transmission empirical coefficient	0.80	0.75
LW high temperature surface correction	Maximum Lapse Rate 10K/100hPa	Maximum Lapse Rate 10K/100hPa
LW Inversion correction	Polar regions and ps < 700 mb excluded	Maximum Inversion limited to 10 K





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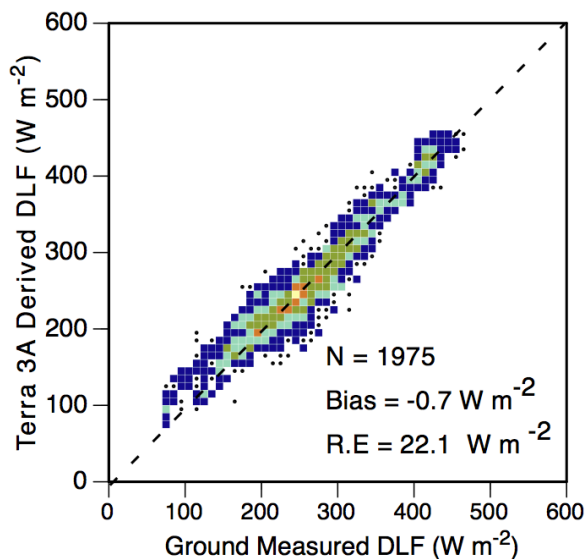


# Comparison between CERES Terra Editions 4A $\beta$ and 3A

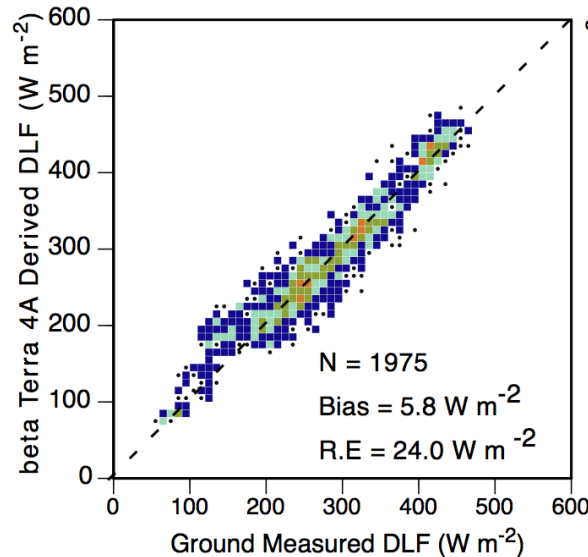
**LW Model B** code changes between Editions 3A and 4A $\beta$ , which includes a constraint method that limits inversions to 10K.

## All-Sky Global

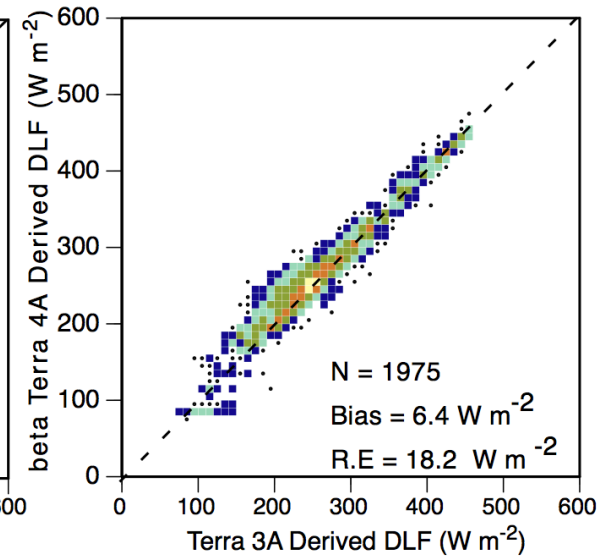
Terra 3A versus Ground



Terra 4A $\beta$  versus Ground

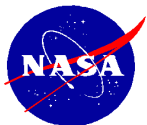


Terra 4A $\beta$  versus Terra 3A



January & April 2001

Includes input differences

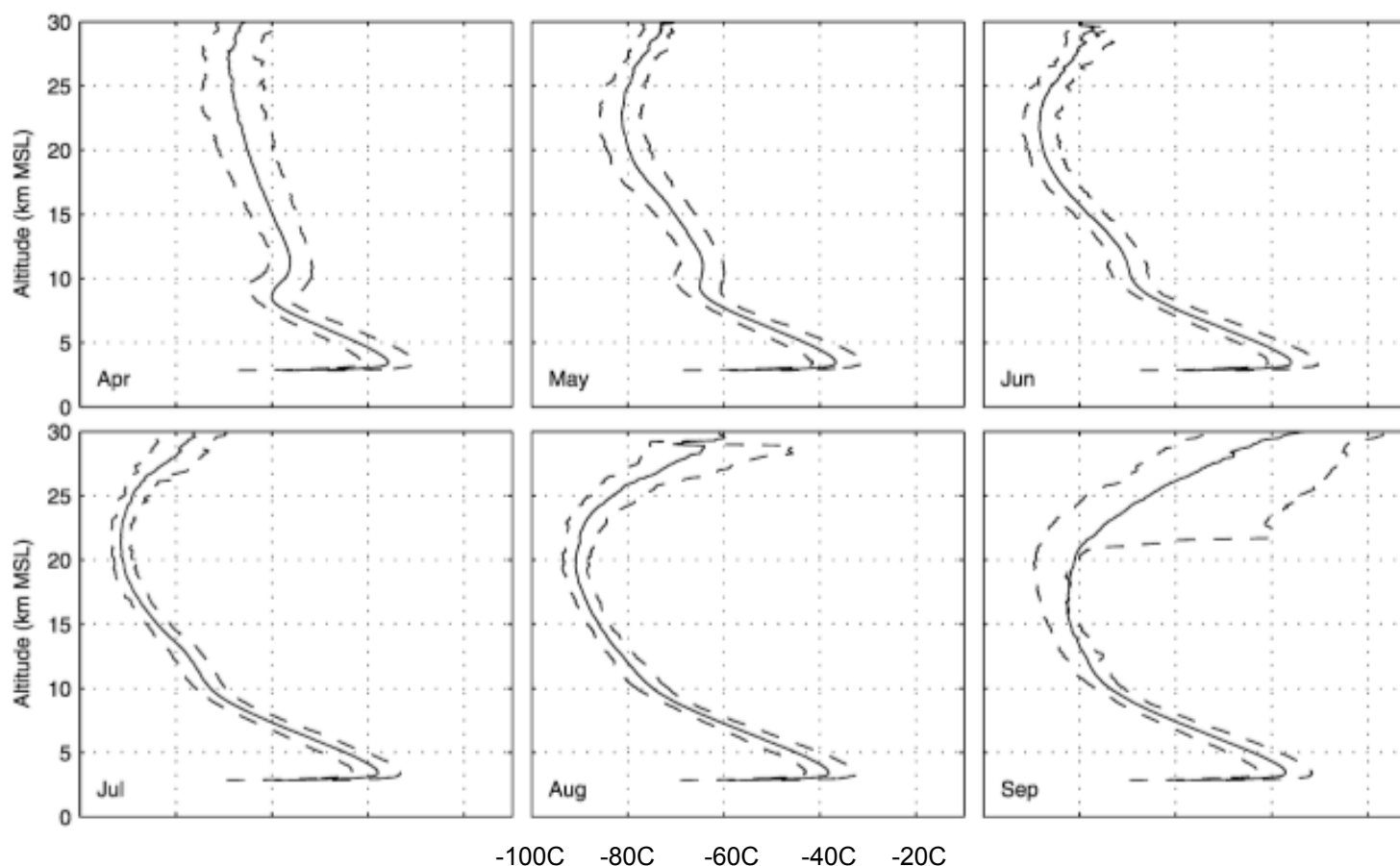


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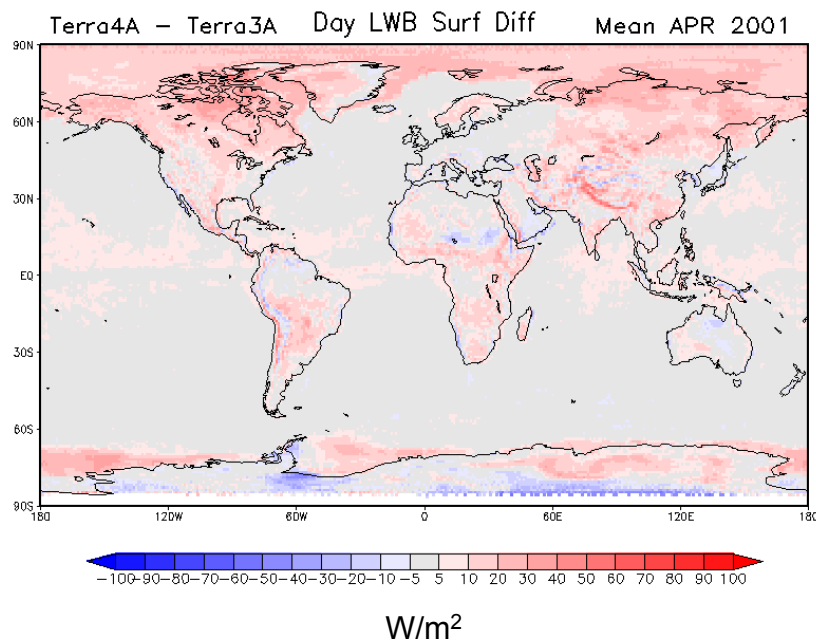
Monthly mean (solid line) atmospheric temperature profiles from 2 m above surface to 30 km above MSL over the South Pole (The dashed lines show the 10<sup>th</sup> and 90<sup>th</sup> percentiles of temperature at each height). Figure adopted from Hudson and Brandt (2005), *J. Climate*, **18**, 1673-1696.



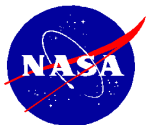
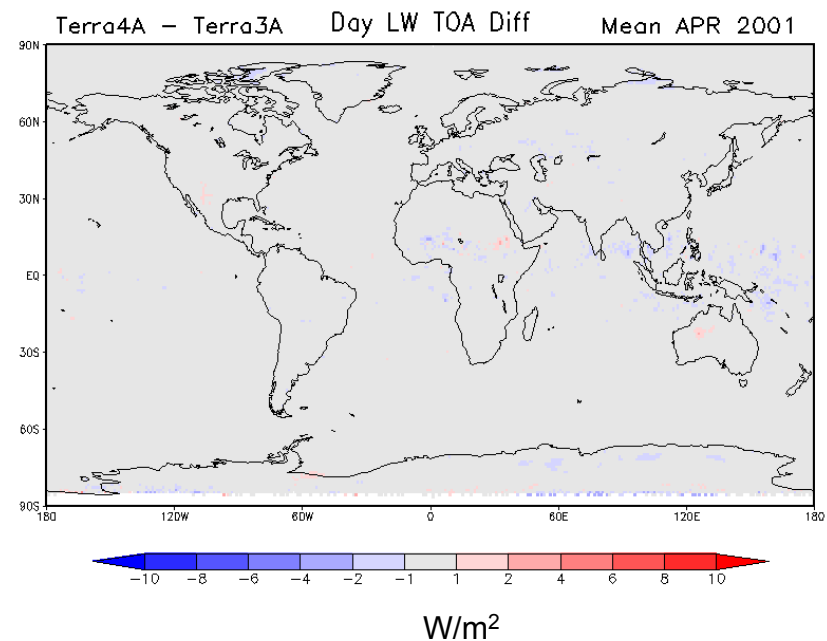


Comparison of the CERES Editions 4A $\beta$  and 3A differences in the daytime downward **LW** surface fluxes with the corresponding differences in the **LW TOA fluxes** for Terra data for April 2001. LW model B is dependent upon the meteorological inputs rather than the TOA fluxes, thus these results are essentially decoupled!

Terra 4A $\beta$  - 3A LW Surface Flux Difference



Terra 4A $\beta$  - 3A LW TOA Flux Difference

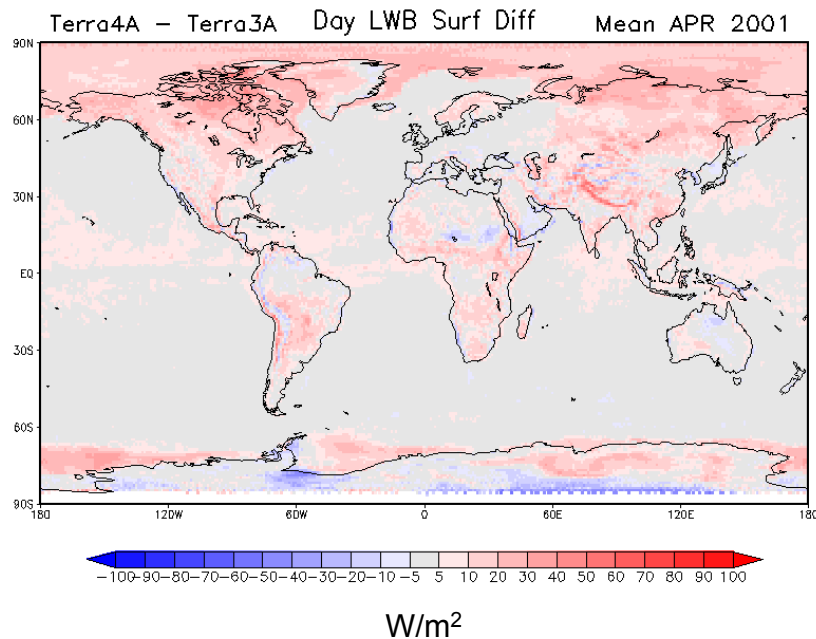


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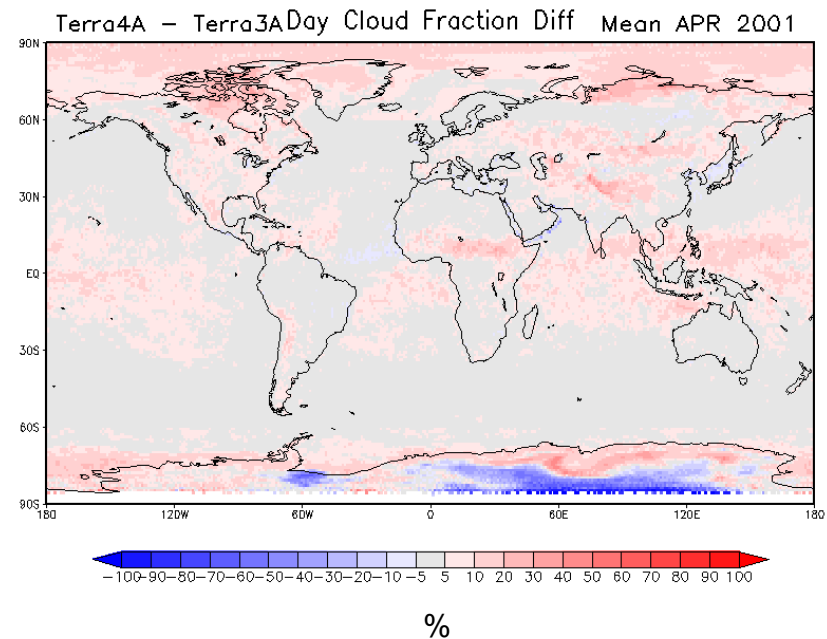


Comparison of the CERES Editions 4A $\beta$  and 3A differences in the daytime downward **LW** surface fluxes with the corresponding differences in the **cloud fractions** for Terra data for April 2001.  
(Edition 4 $\beta$  versus Edition 2 clouds)

Terra 4A $\beta$  - 3A LW Surface Flux Difference



Terra 4A $\beta$  - 3A Cloud Fraction

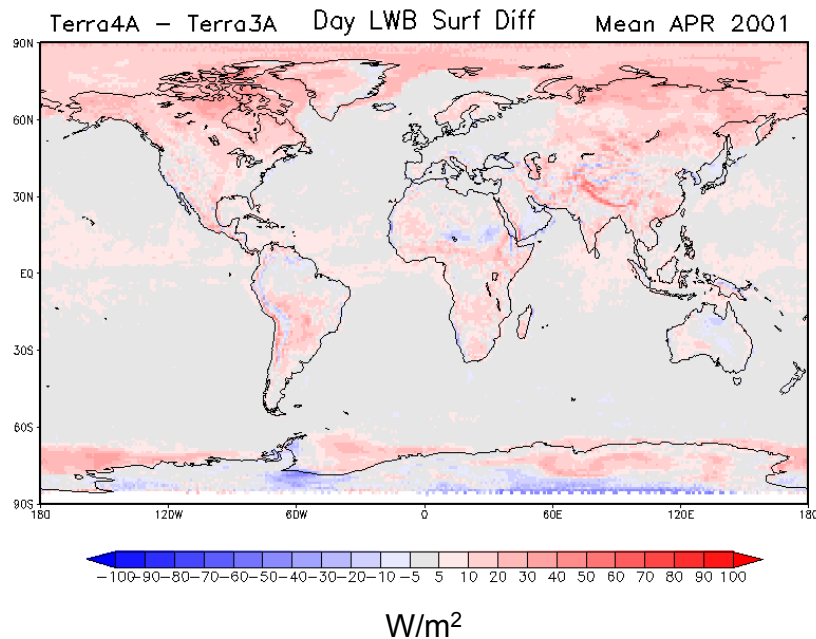


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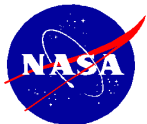
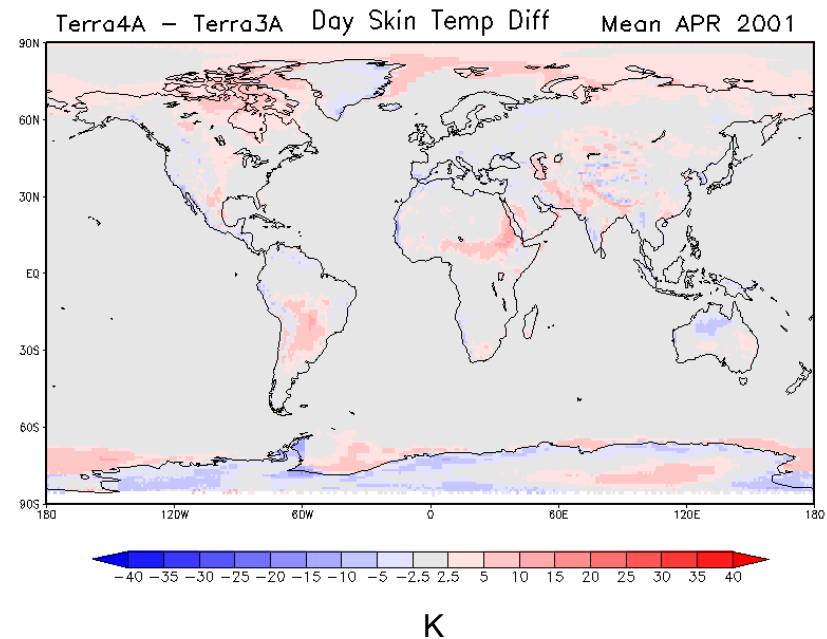


Comparison of the CERES Editions 4A $\beta$  and 3A differences in the daytime downward **LW** surface fluxes with the corresponding differences in the **surface temperature** for Terra data for April 2001.  
(GEOS 5.2.0 versus GEOS 5.4.0 temperatures)

Terra 4A $\beta$  - 3A LW Surface Flux Difference



Terra 4A $\beta$  - 3A Surface Temperature

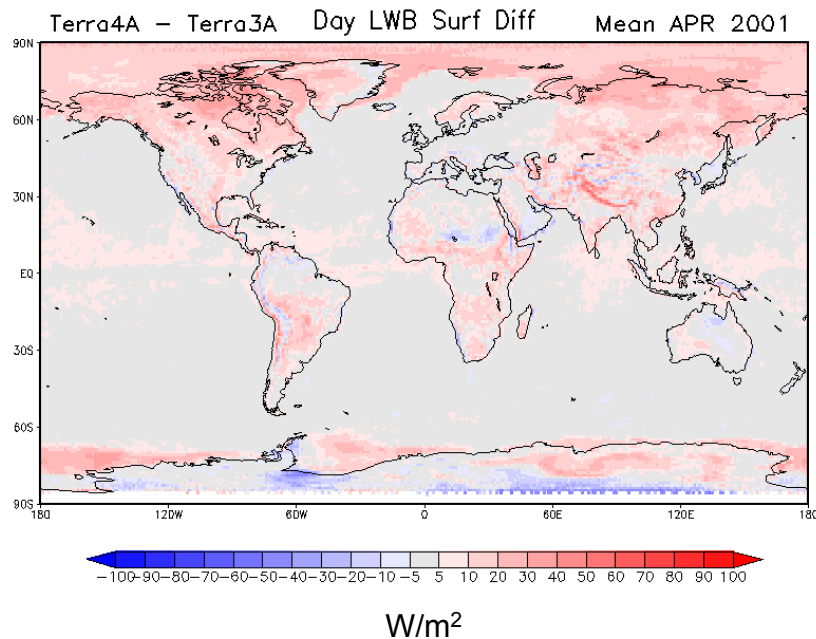


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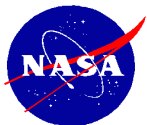
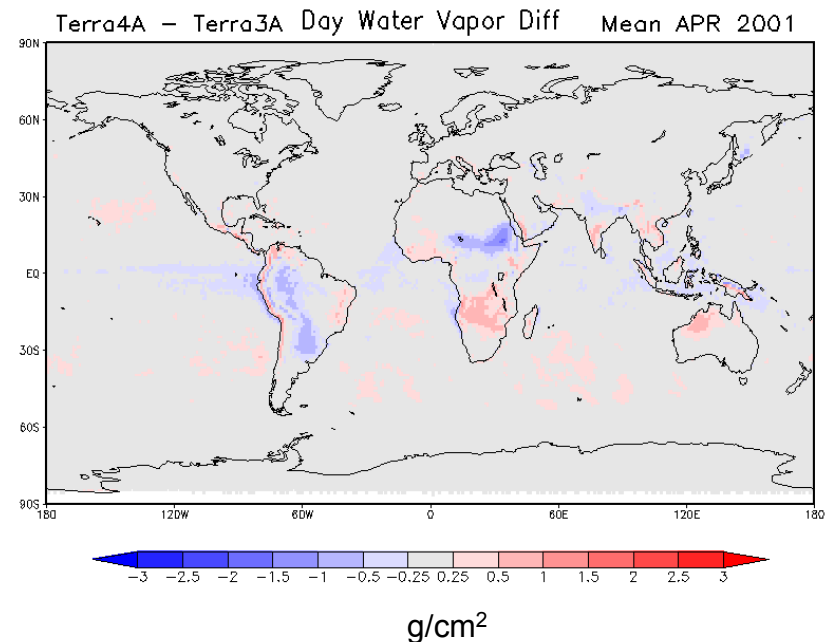


Comparison of the CERES Editions 4A $\beta$  and 3A differences in the daytime downward **LW** surface fluxes with the corresponding differences in the **water vapor amount** for Terra data for April 2001.  
(GEOS 5.2.0 versus GEOS 5.4.0 water vapor amounts)

Terra 4A $\beta$  - 3A LW Surface Flux Difference



Terra 4A $\beta$  - 3A Water Vapor Amount



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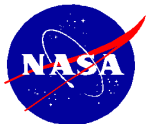


## Results of Recent LW Model Improvements

For the condition involving surface temperatures that greatly exceed the overlying air temperatures, constraining the lapse rate to 10 K/100 hPa (roughly the dry adiabatic lapse rate) has significantly improved the results, see Gupta et al. (2010).

For conditions involving surface temperatures that are much below the overlying air temperatures (strong inversions), limiting the inversion to a maximum of 10 K for the downward flux calculations provides the best results for all conditions.

Edition 4 $\beta$  inputs into the LW model are providing the expected results.



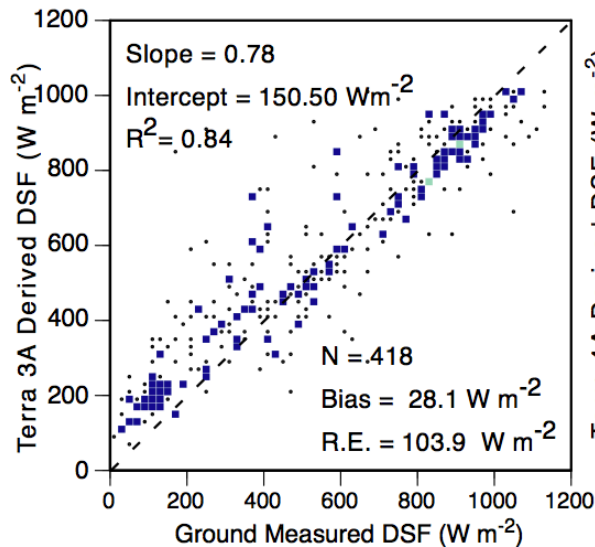
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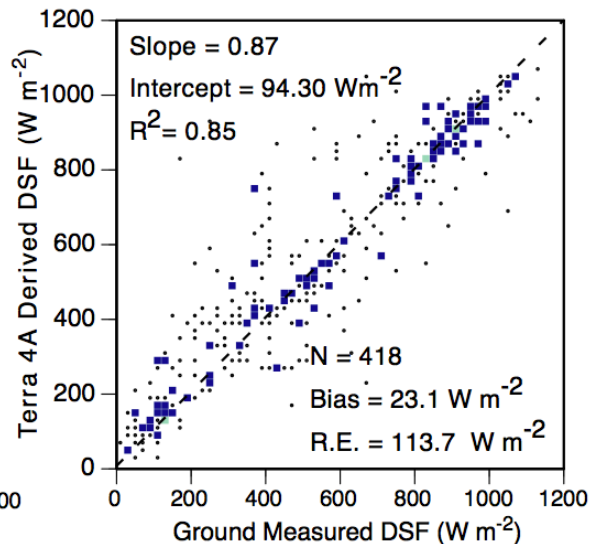
Comparison between CERES Terra Editions 4A $\beta$  and 3A  
 SW Model B code changes from Editions 2B through 3A to 4A $\beta$  include  
 the replacement of the input albedo maps, aerosols, Rayleigh molecular  
 scattering formula, and cloud transmission coefficient.

### All-Sky Non-Polar

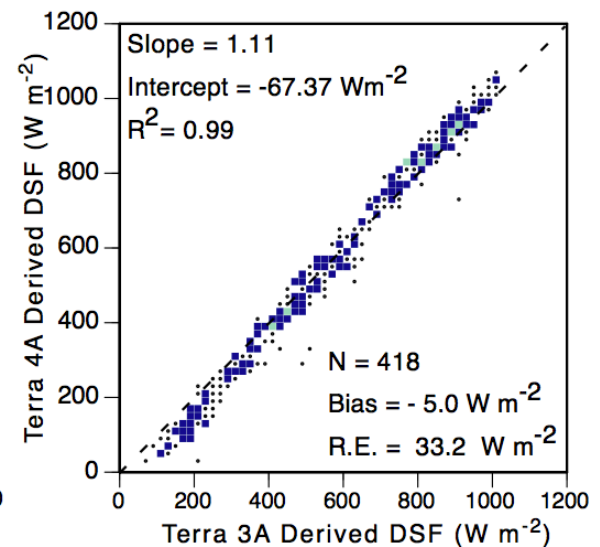
Terra 3A versus Ground



Terra 4A $\beta$  versus Ground

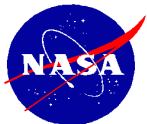


Terra 4A $\beta$  versus Terra 3A



January & April 2001

Includes input differences



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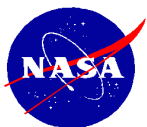
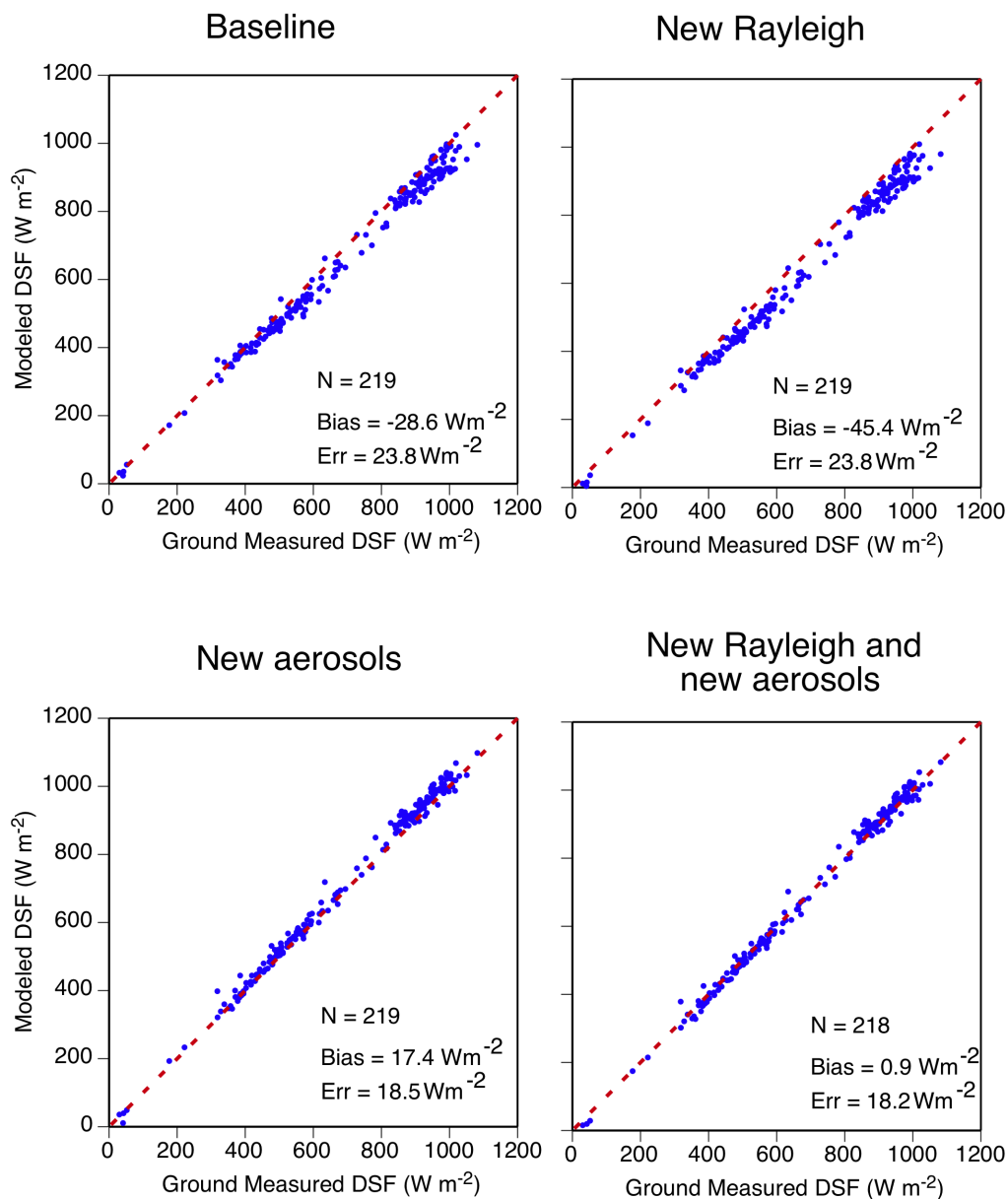


# Comparison between surface-measured and CERES-derived fluxes: Clear-Sky

Clear-sky results for comparisons among the results for a) WCP-55 aerosols & old Rayleigh algorithm, b) WCP-55 aerosols & new Rayleigh algorithm, c) MATCH aerosols & old Rayleigh algorithm, and d) MATCH aerosols & new Rayleigh algorithm.

For the clear-sky case, the new formulation with the MATCH aerosols & the new Rayleigh algorithm shows a remarkable improvement.

January & July 2004 results



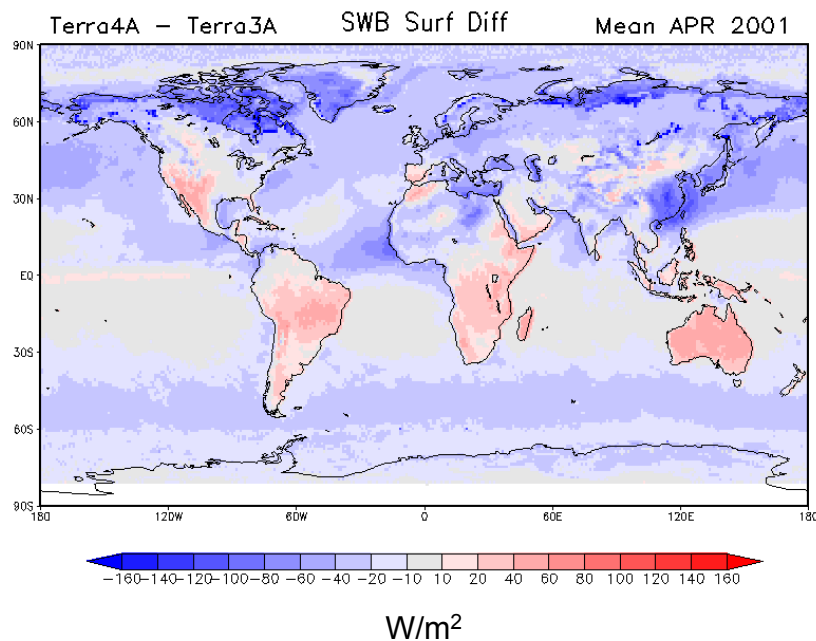
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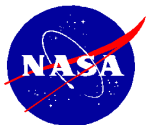
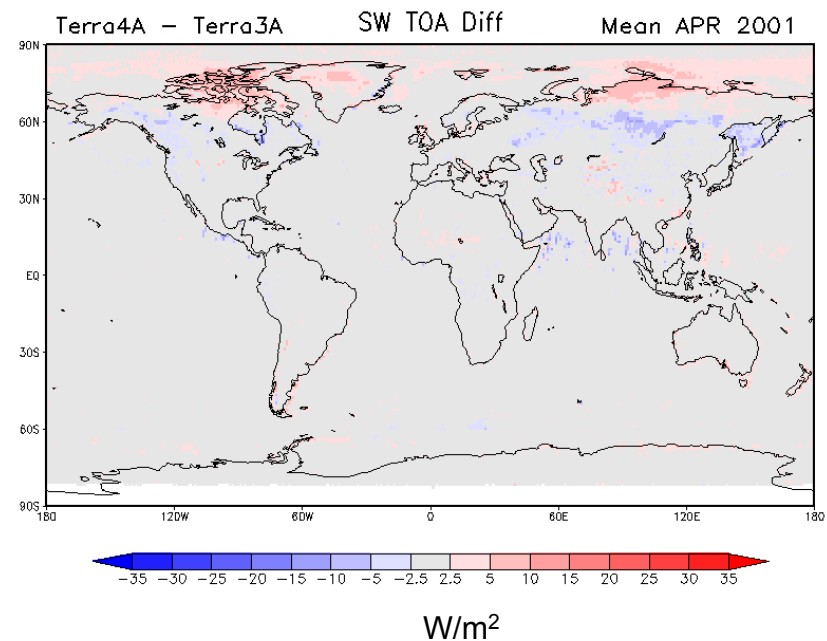


Comparison of the CERES Editions 4A $\beta$  and 3A differences in the daytime downward **SW** surface fluxes with the corresponding differences in the **SW TOA fluxes** for Terra data for April 2001.

Terra 4A $\beta$  - 3A SW Surface Flux Difference



Terra 4A $\beta$  - 3A SW TOA Flux Difference

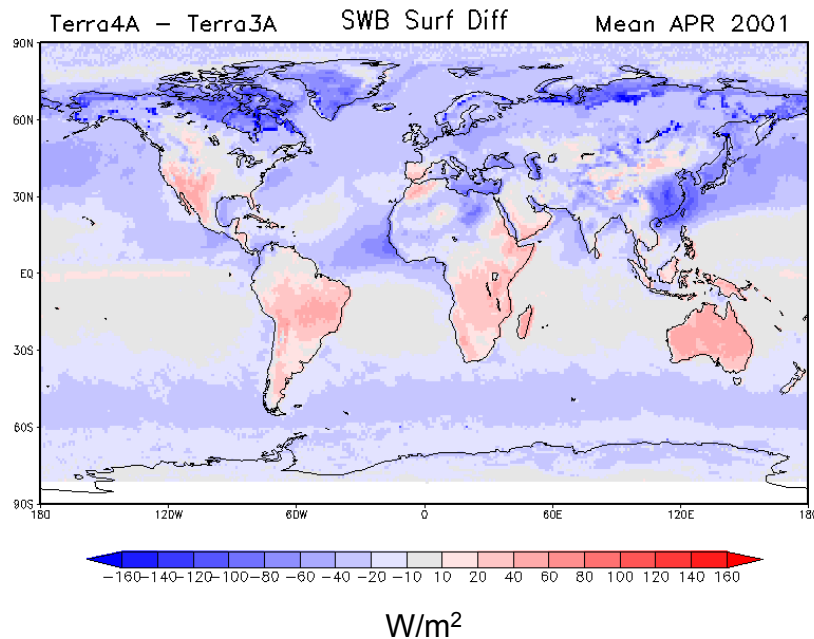


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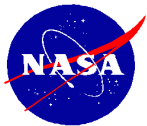
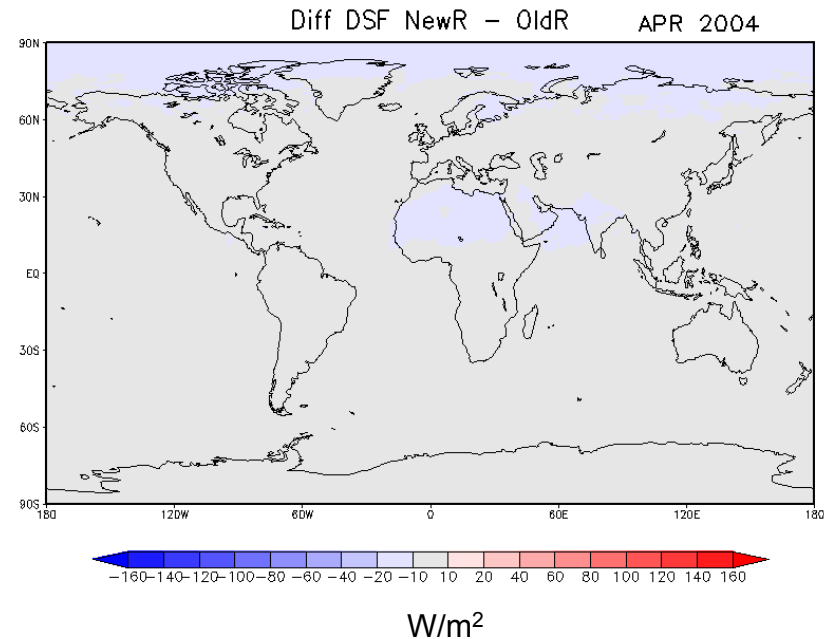


Comparison of the CERES Editions 4A $\beta$  and 3A differences in the daytime downward **SW** surface fluxes with the corresponding differences in the **Rayleigh formula** for Terra data for April 2001. (Revision in Rayleigh formula has persistent but modest impact)

Terra 4A $\beta$  - 3A SW Surface Flux Difference



Terra 4A $\beta$  - 3A Rayleigh Formula

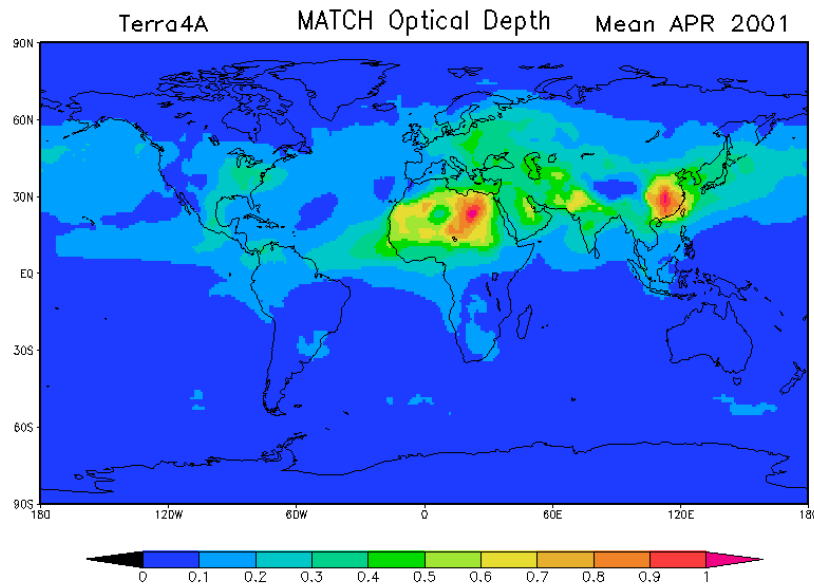


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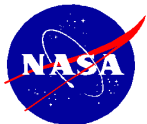
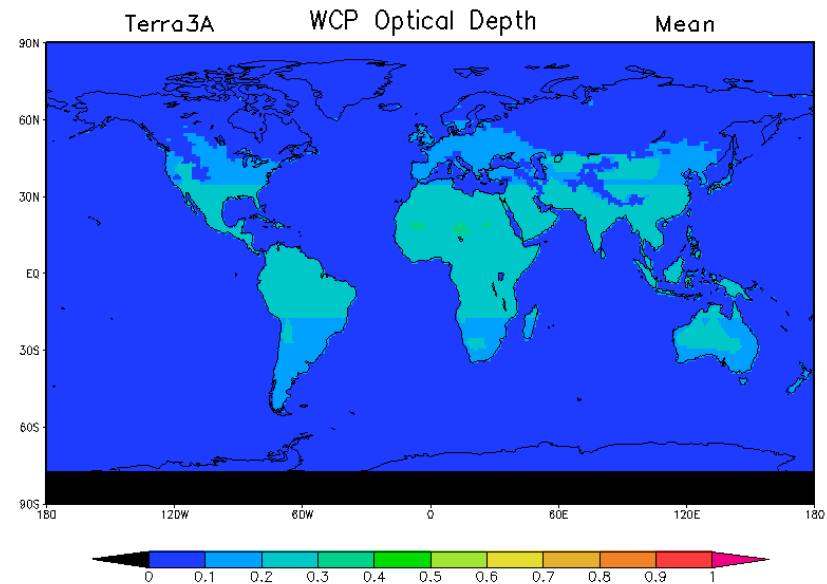


Comparison of monthly averaged **aerosol optical depths**  
used in CERES Editions 4A $\beta$  and 3A  
for the **SW** surface fluxes for Terra data in April 2001.

Terra 4A $\beta$  MATCH Monthly Aerosols



Terra 3A (WCP-55 Aerosols)

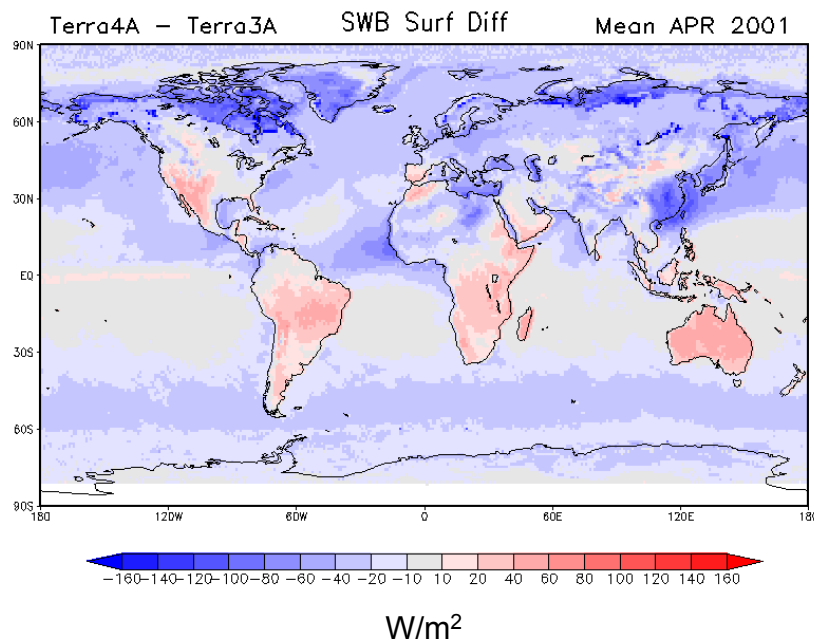


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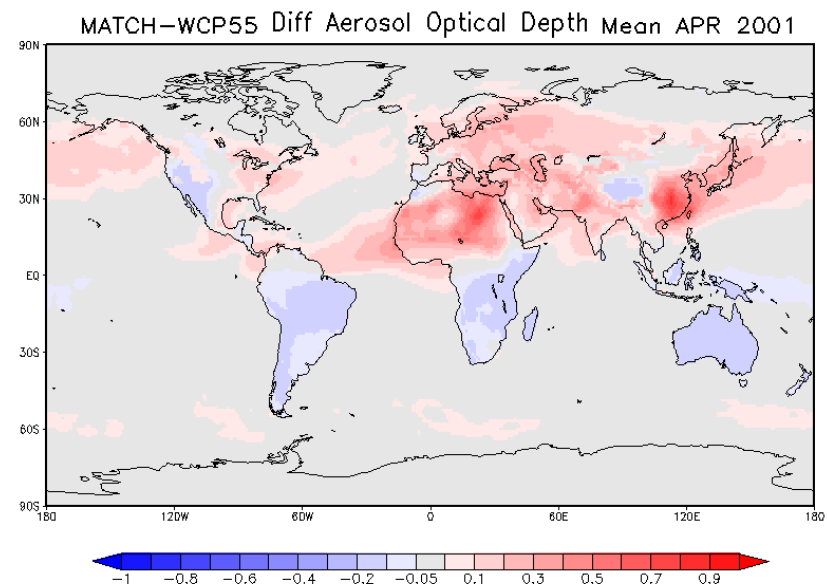


Comparison of the CERES Editions 4A $\beta$  and 3A differences in the daytime downward **SW** surface fluxes with the corresponding differences in the **aerosol optical depths** for Terra data for April 2001.

Terra 4A $\beta$  - 3A SW Surface Flux Difference



Terra 4A $\beta$  (MATCH) - 3A (WCP-55)

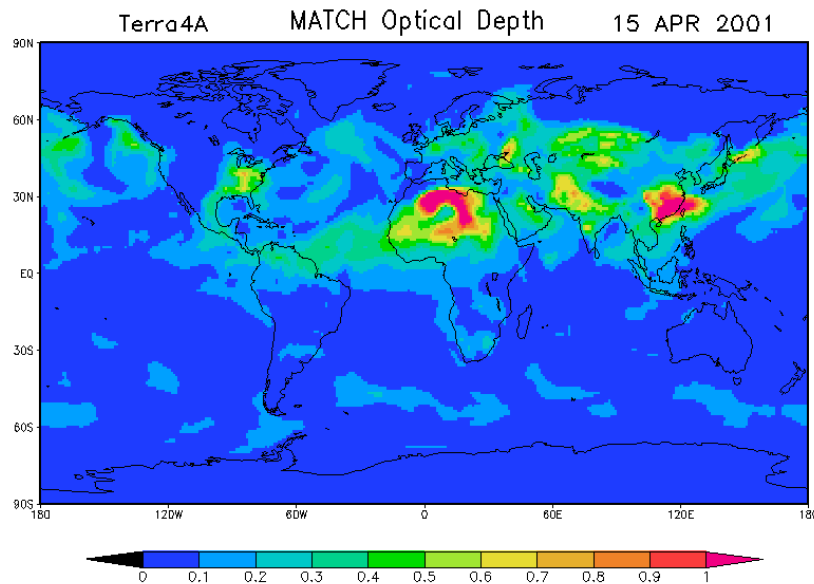


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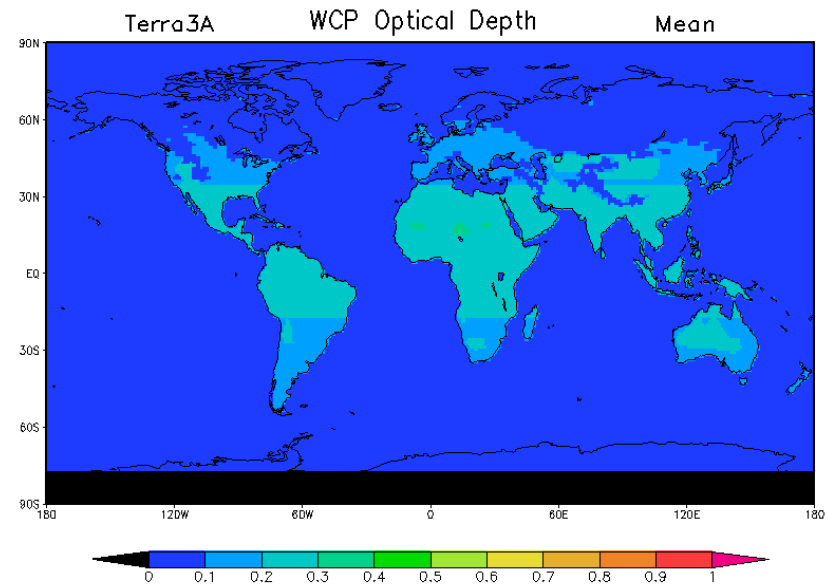


Comparison of monthly averaged **aerosol optical depths**  
used in CERES Editions 4A $\beta$  and 3A for the  
**SW** surface fluxes for Terra data in April 15, 2001.  
(Change to MATCH daily aerosols causes dominant impact )

Terra 4A $\beta$  MATCH April 15 Aerosols



Terra 3A (WCP-55 Aerosols)

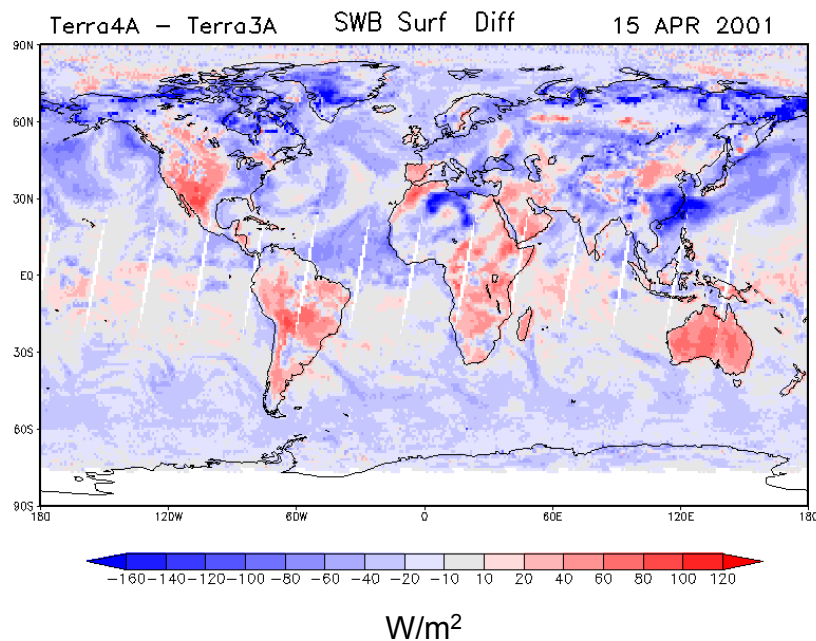


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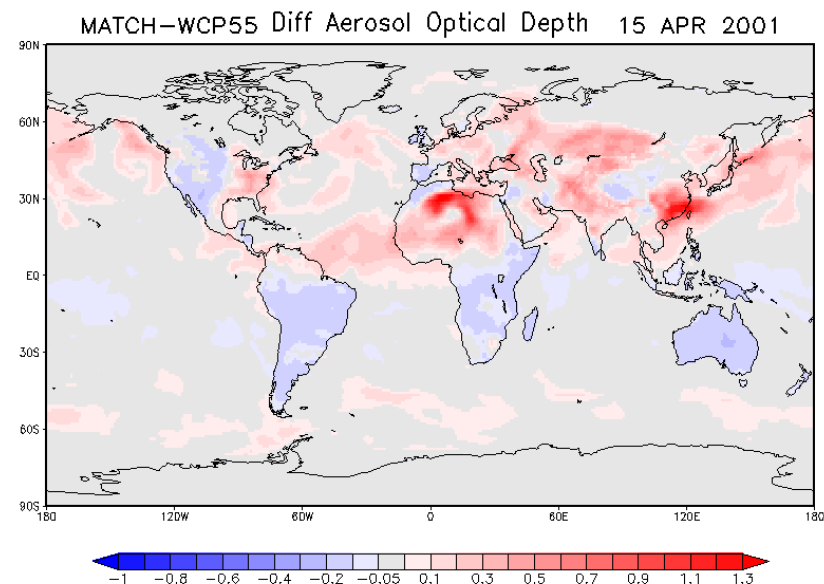


Comparison of the CERES Editions 4A $\beta$  and 3A differences in the daytime downward **SW** surface fluxes with the corresponding differences in the **aerosol optical depths** for Terra data for April 15, 2001.

Terra 4A $\beta$  - 3A SW Surface Flux Difference



Terra 4A $\beta$  (MATCH) - 3A (WCP-55)



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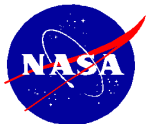


## Results of Recent SW Model Improvements and Course of Action for the Future

Simultaneously replacing the original WCP-55 aerosols with the MATCH aerosols, and the original Rayleigh molecular scattering formulation with an improved Rayleigh molecular scattering formulation has significantly improved the surface SW flux calculations for clear through partly cloudy sky conditions.

To account for the short term variability of aerosol properties, we have incorporated the daily aerosol properties into SW Model B.

Results for the mostly cloudy to overcast conditions show some improvement gained by revising the  $a_0$  coefficient but strongly suggest that further work on the cloud transmittance calculation is necessary. Our attention is currently focused on the formulae used for the cloud transmittance and the overcast albedo.



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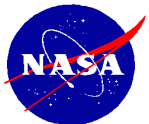




# Conclusions

Validation studies have shown that revisions to both the LW and SW algorithms appear to be working well, though further revisions to the cloud transmission formula and/or overcast albedo method appear to be needed for SW Model B.

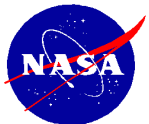
A preliminary analysis of the LW and SW surface only flux algorithm results using the Edition 4 $\beta$  inputs, especially those from the Clouds Subsystem, indicate improved accuracies for most locations.



# CERES Journal Publication Citations

For all publications whether funded by CERES or using CERES data, please include the word “CERES” in the keyword list as this will facilitate listing your publication in the CERES formal publication web-page list (<http://ceres.larc.nasa.gov/docs.php>).

When any paper, technical report, or book chapter has either been accepted for publication or been published, please notify the CERES group of this publication by contacting Anne Wilber at ([anne.c.wilber@nasa.gov](mailto:anne.c.wilber@nasa.gov)).



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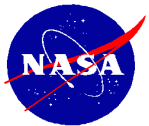
## CERES Journal Publication Citation Values (2/1/2012)

			c1	c2	c3
Year	All References	Journal Articles	Citation	Citation	Citation
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2010	65	61	194	1302	2914
2009	48	47	520	1118	2502
2008	62	61	600	954	2135
2007	39	31	330	805	1802
2006	44	40	1076	591	1323
2005	49	47	1349	530	1186
2004	39	39	1032	409	915
2003	51	48	1485	379	848
2002	78	69	4070	353	790
2001	50	44	2054	202	452
2000	34	32	1095	218	488
1999	24	21	661	155	347
1998	20	20	3863	79	177
1997	9	9	275	44	99
1996	5	5	637	47	105
1995	1	1	17	13	29
1994	1	1	3	11	24
1993	6	6	35	0	0
Total	687	628	19336	8640	19336

Citation c1 = # of citations for papers published in that year.

Citation c2 = # of citations in ISI for papers published in all years using a specified set of categories.

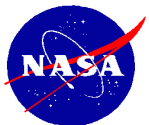
Citation c3 = renormalized # of citations for papers published in all years so that the total number of citations in c3 = c1



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## Backup Slides

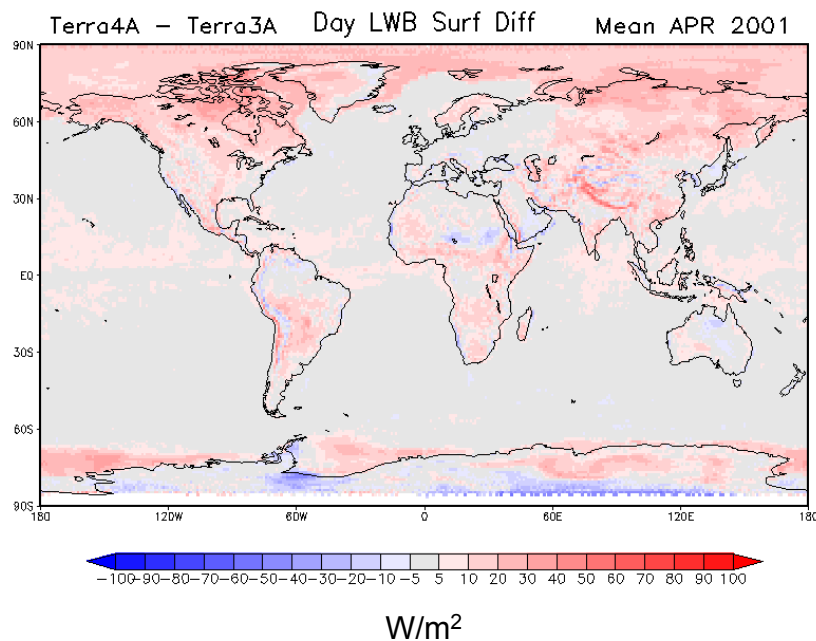


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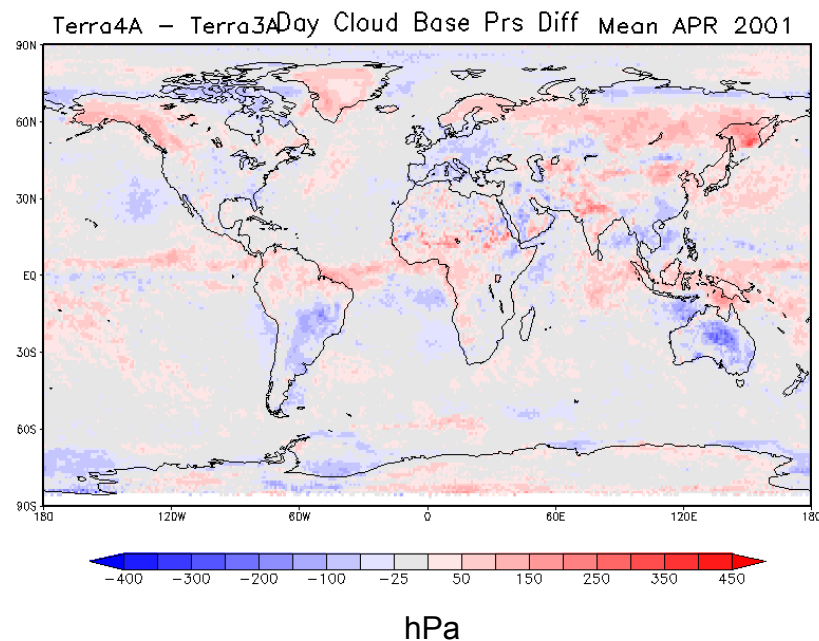


Comparison of the CERES Editions 4A $\beta$  and 3A differences in the daytime downward **LW** surface fluxes with the corresponding differences in the **cloud base pressure** for Terra data for April 2001.

Terra 4A $\beta$  - 3A LW Surface Flux Difference



Terra 4A $\beta$  - 3A Cloud Base Pressure

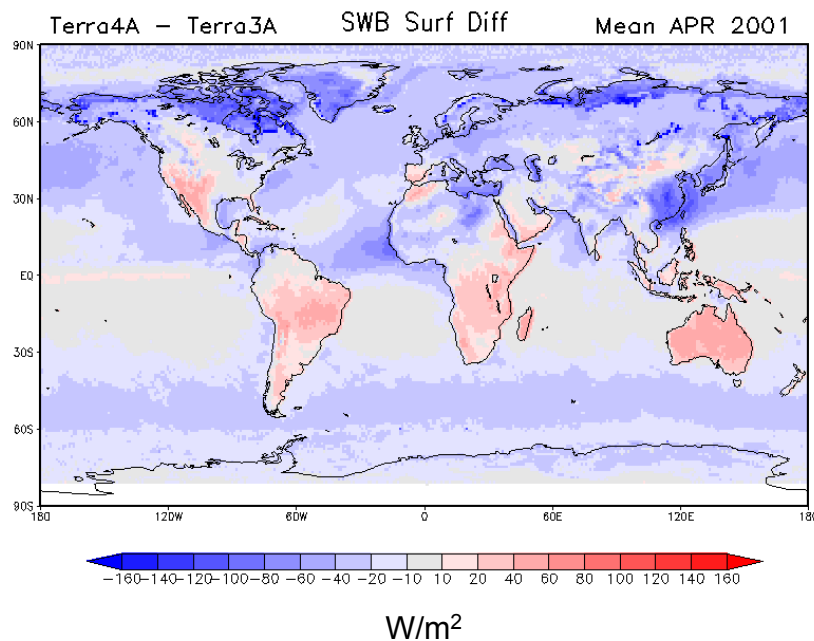


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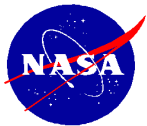
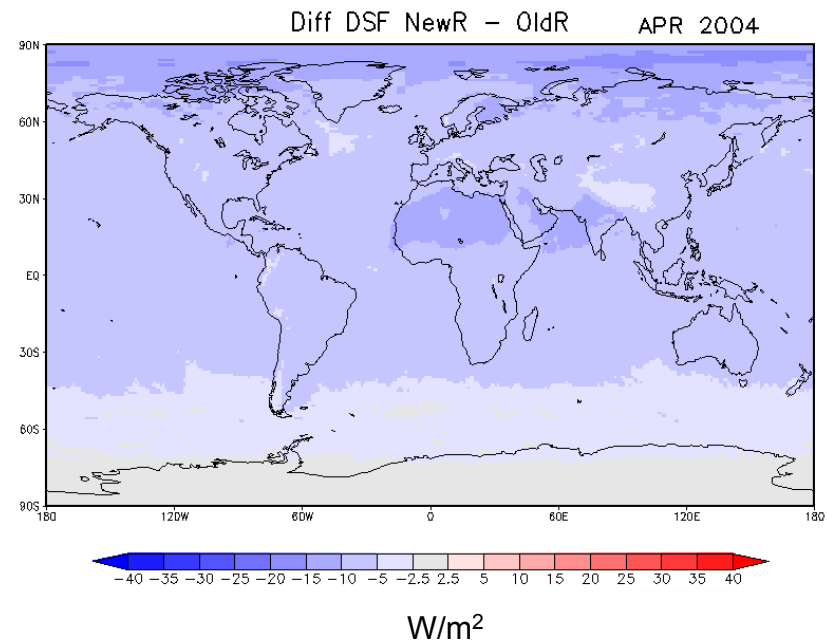


Comparison of the CERES Editions 4A $\beta$  and 3A differences in the daytime downward **SW** surface fluxes with the corresponding differences in the **Rayleigh formula** for Terra data for April 2001. (Revision in Rayleigh formula has persistent but modest impact)

Terra 4A $\beta$  - 3A SW Surface Flux Difference



Terra 4A $\beta$  - 3A Rayleigh Formula

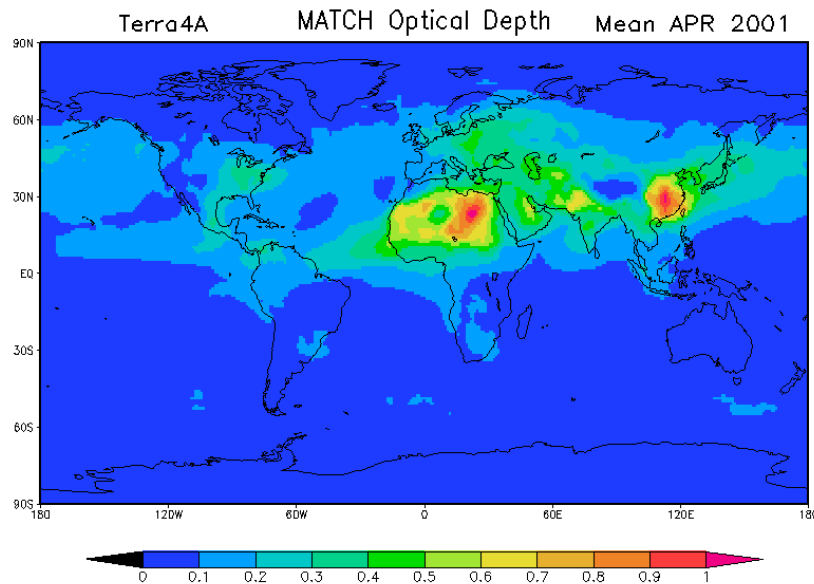


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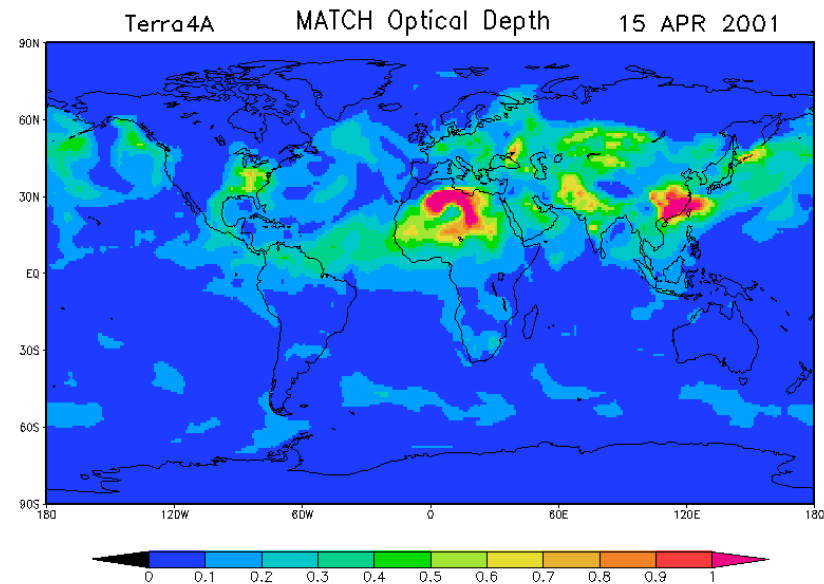


Comparison of monthly averaged aerosol optical depths used in CERES Editions 4A $\beta$  and daily aerosol optical depths for the SW surface fluxes for Terra data in April 2001.

Terra 4A $\beta$  MATCH Monthly Aerosols



Terra 4A $\beta$  MATCH Daily Aerosols



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